

REMARKS

Claims 1-8 and new Claims 9-14 are active in the present application. Reconsideration is respectfully requested.

The present invention relates to a method of heterogeneously catalyzing the partial gas phase oxidation of acrolein to acrylic acid.

Applicants' representative wishes to thank Examiner Puttlitz for the helpful and courteous interview of December 2, 2004. As a result of the discussion, it is believed that the issues in the case have been clarified and that the prosecution of the case has been materially advanced.

Claim Amendments

All of the claims have been amended to improve upon the form of the claims. New Claims 9-14 have been added and support for these claims can be found on page 5 of the text of the specification. Entry of the amendments is respectfully requested.

Claim Rejection, 35 USC 112, Second Paragraph

Claim 1 has been amended to state that the process of the claim is performed by passing a "starting gas mixture" over a catalyst in one reaction stage. The amended language presented is believed sufficient to clarify the claim. Claim 1 has been further clarified by deleting the term "overall" from the claim and by specifying that the active composition refers to the catalyst in each reaction zone. Finally, it is clear that the entire process is directed to the production of acrylic acid, and therefore, the selectivity of the conversion process to acrylic acid is an inherent parameter that is to be determined based on data obtained from any given replication of the process as claimed. Accordingly, the issues that have been raised are believed overcome and withdrawal of the rejection is respectfully requested.

Invention

The present invention is directed to a process for partially oxidizing acrolein to acrylic acid in the gas phase under heterogeneous catalysis by passing a starting gas mixture which comprises acrolein, molecular oxygen and at least one inert gas containing at least 20 % by volume of molecular nitrogen and contains molecular oxygen and the acrolein in a molar $O_2:C_3H_4O$ ratio of ≥ 0.5 through one reaction stage over a fixed catalyst bed which is arranged in two spatially successive reaction zones A,B, the temperature of reaction zone A being a temperature in the range from 230 to 320° C and the temperature of reaction zone B likewise being a temperature in the range from 230 to 320° C, whose active composition in each reaction zone is at least one multimetal oxide comprising the elements Mo and V, in such a way that reaction zone A extends to an acrolein conversion of ranging from 45 to 85 mol % and, on single pass of the starting gas mixture through the fixed catalyst bed, the acrolein conversion is ≥ 90 mol % and the selectivity of to acrylic acid, based on acrolein converted, is ≥ 90 mol %, the chronological sequence in which the starting gas mixture flows through the reaction zones corresponding to the alphabetic sequence of the reaction zones, wherein

a) the hourly space velocity of the acrolein contained in the starting gas mixture on over the fixed catalyst bed is ≤ 145 l (STP) of acrolein/l of fixed catalyst bed·h and ≥ 70 l (STP) of acrolein/l of fixed catalyst bed·h,

b) the volume-specific activity of the fixed catalyst bed is either constant or increases at least once in the flow direction of the reaction gas mixture over the fixed catalyst bed, and

c) the difference $T^{\max A} - T^{\max B}$, determined from the highest temperature $T^{\max A}$ which the reaction gas mixture has within the reaction zone A and the highest temperature $T^{\max B}$ which the reaction gas mixture has within reaction zone B, is $\geq 0^\circ$ C. The result of the present process is an acrylic acid product that is produced in a very high selectivity.

Prior Art Rejection, 35 USC 103(a)

Claims 1-8 stand rejected based on 35 USC 103 as obvious over Unverricht et al, U. S. Patent 6,403,829 in view of Lonzetta et al, U. S. Patent 6,620,968. This ground of rejection is respectfully traversed.

It is clear that the Unverricht et al patent is relevant prior art to the present invention, because it discloses a catalytic process for the production of acrylic acid by the oxidation of acrolein in the gas phase that also contains molecular oxygen and an inert gas in two successive reaction zones. A requirement of the disclosed process is that the loading of the fixed bed catalyst in the two successive reaction zones A and B is ≥ 150 l (STP) of acrolein/l of fixed catalyst bed-h (col 2, lines 44-46). Further, as described at column 2, lines 60-65, the temperature of the second reaction zone B is at least 10° C above the 245 to 260° C temperature of reaction zone A. (The temperature of reaction zone B is normally from 265 to 285° C.) As disclosed at the top of column 3, the difference in reaction temperature between the two zones is such that the temperature difference will not be more than 40° C.

The requirements of the present process, as claimed, however are that the loading of the fixed bed catalyst in the two successive reaction zones A and B is ≤ 145 l (STP) of acrolein/l of fixed catalyst bed-h and that the difference $T^{\max A} - T^{\max B}$, determined from the highest temperature $T^{\max A}$ which the reaction gas mixture has within the reaction zone A and the highest temperature $T^{\max B}$ which the reaction gas mixture has within reaction zone B, is $\geq 0^{\circ}$ C. It is therefore evident that one clearly distinct difference between the present process and the process of the patent, which is important, is in the loading of the fixed bed catalysts in the two reaction zones of the two processes. In the process of the patent the loading of catalyst is stated as ≥ 150 l (STP) of acrolein/l of fixed catalyst bed-h, whereas in the present invention the loading of catalyst is claimed as ≤ 145 l (STP) of acrolein/l of fixed catalyst bed-h, which is

incorrectly stated at page 4, lines 6-9 of the outstanding Office Action as ≥ 145 l (STP) of acrolein/l of fixed catalyst bed·h.

It is also clear from a consideration of the disclosure of Unverricht et al that there is no teaching or suggestion of limitation (c) of the present claims that specifies that the difference $T^{\max A} - T^{\max B}$, determined from the highest temperature $T^{\max A}$ which the reaction gas mixture has within the reaction zone A and the highest temperature $T^{\max B}$ which the reaction gas mixture has within reaction zone B, must be $\geq 0^\circ$ C. No mention is made in the patent of $T^{\max A}$ and $T^{\max B}$ values. Unverricht et al only mentions that the temperature of reaction zone B be at least 5° C, preferably 10° C, and particularly 20° C above the temperature of reaction zone A. In this context it discloses that the temperature range of zone A is 230° to 270° C and that the temperature range of zone B is 250° to 300° C. The greater temperature level of zone B compared to the temperature level of zone A is consistent with the requirement of Unverricht et al that the set temperature level of zone B be at least 5° C, preferably 10° C, and particularly 20° C above the set temperature of reaction zone A. There is no teaching or suggestion in the reference of operating both zones in the same temperature range as done in the present method, where, nevertheless, it is possible to control the temperature of each bed so as to meet the $T^{\max A} - T^{\max B}$ limitation of the present claims. Note that the last experiment in the table on page 28 of the present specification meets the requirement of the patent in that the temperature difference between zones A and B is 21° C with the temperature of zone B being greater than the temperature of zone A. However, here, the acrolein space velocity is 147 l(STP)/l·h, which is just under the limitation of 150 l(STP)/l·h of the reference. (Note, that $T^{\max A} - T^{\max B}$ is -32° C which does not meet the limitation of the present claims.) A comparison of the selectivity value of the last experiment with the other selectivity values of the table shows that the experiment closest to the patent results in the lowest selectivity value. The results in the table are consistent

with the statement made on page 5, lines 1-6 of the present specification that, in contradistinction to Unverricht et al, in the present process the value of $T_B - T_A$ is $\leq 0^\circ \text{C}$.

The Lonzetta et al patent does not improve upon the deficiencies of Unverricht et al, because it is directed to a distinctly different gas phase oxidation process that occurs in two distinct stages, wherein a reactive hydrocarbon such as propylene, isobutylene and mixtures thereof are oxidized over an oxidation catalyst to (meth)acrolein and then in a second stage the (meth)acrolein is oxidized over an oxidation catalyst to (meth)acrylic acid. Clearly, the first oxidation stage of converting a reactive hydrocarbon gas is irrelevant to the present process, and thus the two reaction temperature ranges disclosed in column 18 of the patent are not germane to the single oxidation step of the present process that occurs in two reaction zones in which acrolein is converted to acrylic acid. Accordingly, the Lonzetta et al patent does not overcome or improve upon the deficiencies of Unverricht et al and withdrawal of the obviousness ground of rejection is respectfully requested.

Double Patenting Rejections

Claims 1-8 stand rejected based on the judicially created doctrine of obviousness-type double patenting in view of Claims 1-8 of copending application Serial No, 10/784,778. This ground of rejection is respectfully traversed.

Applicants maintain to the contrary that the presently claimed invention is in no manner obvious over Claims 1-8 of the cited copending application. The present invention is directed to a very specific process of oxidizing acrolein in the gas phase in two sequential reaction zones in the presence of a Mo and V containing catalyst, wherein the hourly space velocity of acrolein in the starting gas mixture must be $\leq 145 \text{ l (STP) of acrolein/l of fixed catalyst bed} \cdot \text{h}$ and the maximum temperatures in the reaction zones A and B must such that the specific maximum temperatures conform to a difference specified by the relationship of $T^{\text{maxA}} - T^{\text{maxB}}$ of $\geq 0^\circ \text{C}$.

On the other hand, the claims of the copending case involve the oxidation of a gas mixture of propene, molecular oxygen and an inert gas to acrolein so that the starting gas mixture of the process is quite different from the starting gas mixture of the present claims. That is, the aldehyde acrolein is the product of the reference, whereas the aldehyde acrolein is the starting organic reactant of the present process! In this context, the reference uses a different Mo containing catalyst for the described oxidation process from the Mo containing gas of the present process. Moreover, the hourly space velocity of the propene in the starting gas mixture is a materially different range of $< 160 \text{ l (STP) of propene/l of fixed catalyst bed-h}$ to $> 90 \text{ l (STP) of propene/l of fixed catalyst bed-h}$ in comparison to the hourly space velocity of acrolein in the present process. Despite some process similarities, one of skill in the art, considering the claimed process of the copending case, would not arrive at the present process of oxidizing a materially different organic compound (an aldehyde) under very specific conditions in view of a process which oxidizes an unsaturated hydrocarbon to the aldehyde. Withdrawal of the rejection is respectfully requested.

Claims 1-8 stand rejected based on the judicially created doctrine of obviousness-type double patenting in view of Claims 1-18 of copending application Serial No. 10/784,825. This ground of rejection is respectfully traversed.

Applicants maintain that the presently claimed invention is in no manner obvious over Claims 1-18 of the cited copending application. The claims of application '825 are also directed to a specific process of oxidizing propene in the gas phase over a Mo, Fe and Bi containing catalyst in several sequential reaction zones. However, there are seven specific conditions that must prevail in the process that is claimed in order to achieve the production of acrolein product in high conversion and selectivity. Most of these conditions are materially different from conditions (a) – (c) of the present claims and it is not at all evident how and why one of skill in the art would be motivated by the claims of the copending application to arrive at

the process of converting acrolein to acrylic acid as presently claimed where several of the conditions of the process of the copending application would have to be significantly modified or eliminated. Certainly, the temperature condition of the last three lines of the process of the copending application, while essential for the oxidative conversion of propene, are irrelevant to the present process. It is therefore believed that the present invention as claimed is not obvious over the claims of the reference and withdrawal of the rejection is respectfully requested.

Claims 1-8 stand rejected based on the judicially created doctrine of obviousness-type double patenting in view of Claims 1-15 of copending application Serial No. 10/799,754. This ground of rejection is respectfully traversed.

The process of the '754 differs from the above-discussed two copending applications , as well as the present process in that the process of the '754 application, is directed to the production of acrylic acid starting with a gas mixture that contains propene as the starting material along with molecular oxygen and an inert gas. Gas flow is conducted through several reaction zones up to a zone D. In the first reaction zone the conversion of propene must be ≥ 90 mol % and the selectivity to the production of acrolein and acrylic acid must be ≥ 90 mol %. Other acrolein conversion levels must be met. Moreover, conditions (a) –(f) must be met in order to achieve high selectivities to acrylic acid product. It is therefore not clear how one of skill in the art, considering the process as claimed in the application, would be motivated to produce acrylic acid from acrolein in a single stage by very significant changes to the process claimed in the copending application. Accordingly, the present process as claimed is not obvious over the claimed process of the '754 application and withdrawal of the rejection is respectfully requested.

Claims 1-8 stand rejected based on the judicially created doctrine of obviousness-type double patenting in view of Claims 1-19 of copending application Serial No. 10/803,897. This ground of rejection is respectfully traversed.

The '897 application claims a method of partially oxidizing acrolein to give acrylic acid under heterogeneous catalyst conditions in the gas phase, wherein two important limitations of the process are: that the fixed bed catalyst consists of at least two partially successive fixed catalyst bed zones, and the volume-specific activity within one fixed bed catalyst zone is substantially constant and increases sharply in the flow direction of the reaction gas mixture at the transition from one fixed catalyst bed zone to another fixed catalyst bed zone, and that the transition from temperature zone A to temperature zone B in the fixed catalyst bed does not coincide with a transition from one fixed catalyst bed to another fixed catalyst bed zone. These two process factors do not appear in the present claims. How then would the skilled artisan, considering the claimed process in '897, be motivated to make a number of very significant changes to the claimed process, including omission of the two limitations mentioned above, to arrive at what is the present process with the expectation of achieving a process that attains a high selectivity to acrylic acid product? In fact, the present process as claimed is markedly different from that of the reference and it is not evident how one of skill in the art would alter the process claimed in the copending application to arrive at the present invention as claimed with the expectation of producing acrylic acid at the attained high selectivities. Withdrawal of the rejection is respectfully requested.

Claims 1-8 stand rejected based on the judicially created doctrine of obviousness-type double patenting in view of Claims 1-19 of copending application Serial No. 10/808,282. This ground of rejection is respectfully traversed.

The claims of the '282 application are directed to a process of oxidizing propene to acrylic acid in the gas phase in two sequential reaction stages. The first stage is arranged in the form of two successive temperature zones A and B with a specific conversion of propene attached to zone A, a single pass propene conversion of ≥ 90 mol % and a selectivity to acrolein and acrylic acid of ≥ 90 mol % and further requires that the hourly space velocity of propene in

the starting gas mixture conducted over catalyst bed 1 is ≥ 90 l (STP) of propene/l of fixed bed catalyst 1·h. The second stage is comprised of catalyst bed 2 and is arranged in two spatially successive temperature zones. Specific conditions of the second stage include a conversion of acrolein in temperature zone C of 45 to 85 mol % and an acrolein conversion of ≥ 90 mol % on single pass of gas mixture entering the second stage through the entire fixed catalyst bed. (The conversion of acrolein here is ≥ 90 mol % and the selectivity to acrylic acid is ≥ 80 mol %.)

Further, the hourly space velocity of acrolein present in the starting gas mixture that flows through fixed catalyst bed 2 is ≥ 70 l (STP) of acrolein/l of fixed bed catalyst 2·h. Again it is not at all clear how one of skill in the art would be so motivated to change the claimed process of the reference, which changes would include exclusion of the specific process requirements mentioned above to arrive at the present process as claimed with the expectation of achieving high selectivities to acrylic acid product. Accordingly, the invention as claimed is not obvious over the claims of the '282 application and withdrawal of the rejection is respectfully requested.

Appl'n No. 107806,460

Reply to the Office Action of October 26, 2004

It is now believed that the application is in proper condition for allowance. Early notice to this effect is earnestly solicited.

Respectfully submitted,

OBLON, SPIVAK, McCLELLAND,
MAIER AND NEUSTADT, P.C.

Norman F. Oblon

A handwritten signature in black ink, appearing to read "FD Vastine". The signature is fluid and cursive, with the first letters of the first and last names being capitalized and prominent.

Frederick D. Vastine
Registration No. 27,013

Customer Number

22850

Tel.: (703) 413-3000

Fax: (703) 413-2220

NFO:FDV